

REMOTE SENSING

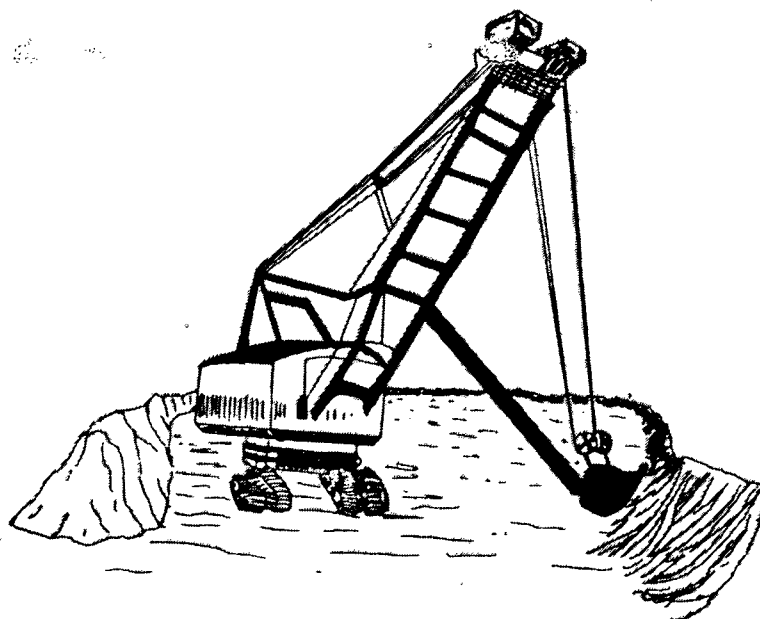
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MINED AREA

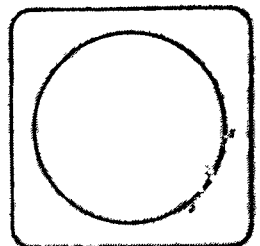
RECLAMATION

APPLICATIONS INVENTORY



EARTH SATELLITE CORPORATION

(EarthSat)



REMOTE SENSING FOR MINED AREA RECLAMATION

Applications Inventory

Interagency Report USGS-218

By

Earth Satellite Corporation
Washington, D. C.

June 1, 1971



Prepared by Earth Satellite Corporation, Washington,
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REMOTE SENSING
FOR
MINED AREA RECLAMATION:
APPLICATIONS INVENTORY

Prepared for
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Bureau of Mines

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I. INTRODUCTION

General Introduction

National demands for environmental protection are mounting along with an increasing public need for energy and a corresponding increase in the mining of mineral fuels. The Bureau of Mines has responsibility for insuring an adequate national minerals supply -- and also responding to public demands to meet this responsibility while maintaining a quality environment.

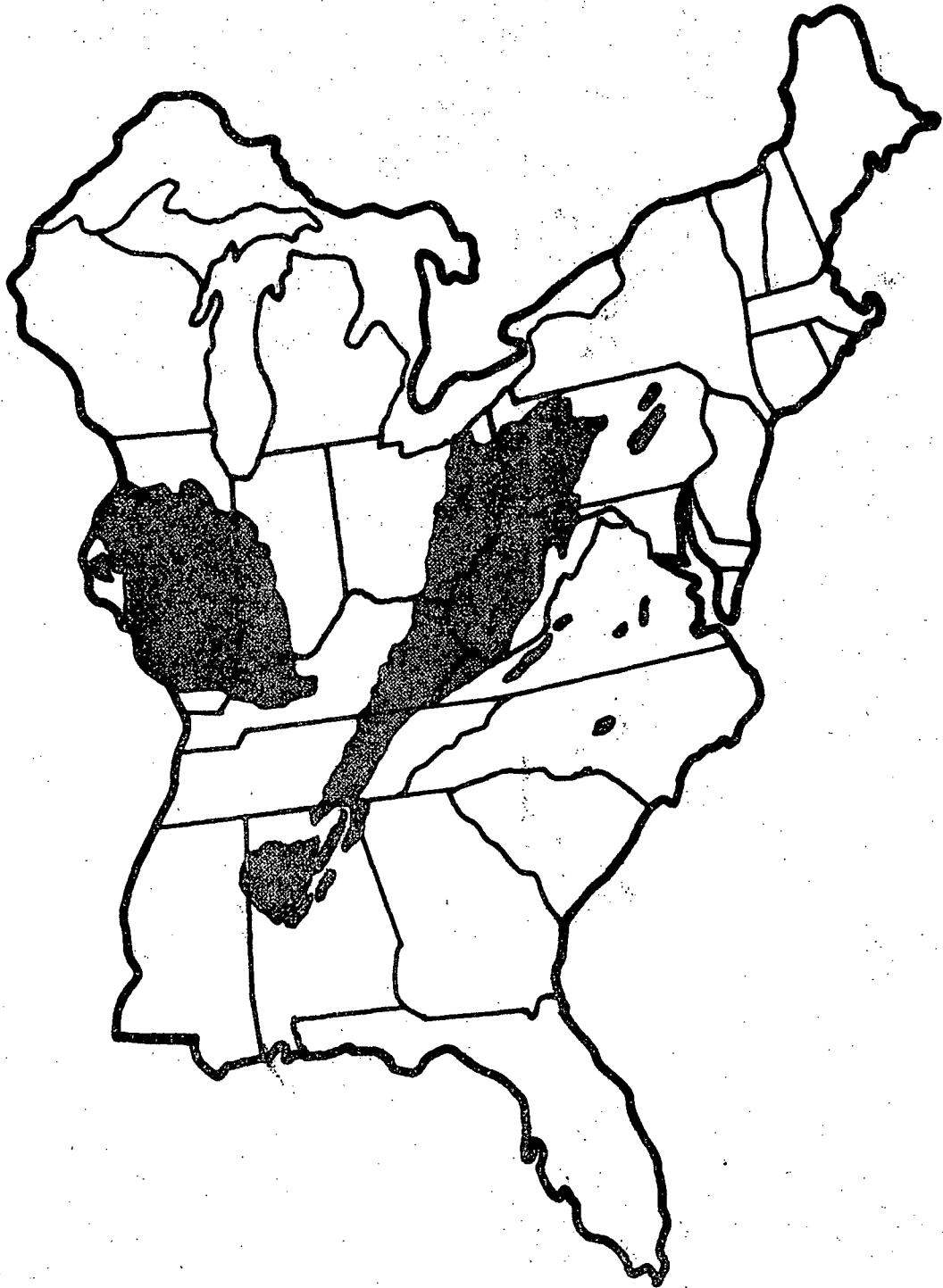
Perhaps the most deleterious effects of mining on the environment have been in the eastern coal-producing areas of the United States (Figure 1). In areas of surface mining and particularly in coal producing regions, new emphasis is now being directed to mined area reclamation.

Reclamation can be generally defined as action taken to return mined lands to productive use or from an undesirable condition. Major reclamation objectives generally include the following:

- Prevent and control erosion
- Facilitate revegetation
- Maintain air and water quality
- Reduce landscape scarring
- Promote proper land use
- Stabilize slopes
- Protect existing structures
- Protect the health and safety of area population

Reclamation of mined lands by definition does not necessarily imply complete restoration or return to original conditions. Restoration to original conditions in some instances might not be warranted or desirable.e.g

MAJOR U.S. EASTERN COAL AREAS



SOURCE: National Coal Association brochure, 1966

FIGURE 1

surface mining has apparently reduced flood hazards in some areas and in some cases has added aesthetically-desirable relief in otherwise flat areas.

Remote sensing defined in its broadest sense is reconnaissance at a distance. Remote sensing devices include, but are not limited to: cameras, thermal infrared scanners, radar transmitters and receivers, laser, radio, and sonar equipment. The purpose of remote sensing is to measure environmental properties and phenomena without physical contact between the measuring devices and the objects (or phenomena) being examined. Remote sensor platforms include airplanes and satellites.

Scientists concerned with reclamation speculate that remote sensing can provide data useful for (1) inventorying the location and affected acreage of mined land; (2) planning reclamation of an area to be surface mined; (3) evaluating the ecological effects of mining; and (4) monitoring the success of mined land revegetation. Repetitive coverage, with the corresponding data extraction from the acquired imagery by skilled interpreters, may prove particularly useful for providing government and the mining industry with information for meeting reclamation objectives.

This study is a preliminary step in detailing mined land reclamation objectives and documenting reclamation-related remote sensing applications known to date. The scales, platforms, and sensors most useful for inventorying coal mined lands and specifically the spectral bands for best meeting mined area information requirements have yet to be defined. It has yet to be proven that remote sensing can be an economically feasible -- possibly even profitable -- part of routine reclamation procedures.

Statement of the Problem

The extent to which remote sensing has been specifically applied to problems of coal mined area reclamation has yet to be defined. While a wide variety of new laws to regulate surface mining are being prepared at federal and state levels, an up-to-date statistical base (inventory) of disturbed land areas does not exist. A first step toward establishing the extent to which synoptic aerial and/or orbital remote sensor imagery can prove useful for conducting a national inventory of mined and reclaimed lands, and for providing data which can be used in limiting environmental damage from coal mining is to evaluate applications-experience to date.

Purpose of the Study

The purpose of this study is to document applications of aerial remote sensing to coal mined area reclamation, and to collect information concerning available data banks.

Study Background

The study was initiated by Mr. Paul M. Marcus of the Division of Environment, United States Bureau of Mines. This study was conducted under Bureau of Mines supervision by Dr. Frank J. Wobber, Director Geosciences and Environmental Applications, and Mr. Donald Garofalo both of Earth Satellite Corporation, Washington, D.C. Particular attention was given to the eastern and midwestern coal producing areas, and specifically Illinois, Indiana, Ohio, Pennsylvania, West Virginia, Maryland, Kentucky, Tennessee and Alabama.

One of the few comprehensive studies of surface mining was conducted by the Bureau of Mines during 1965 to 1966, and published in 1967.^{/1/} The report, Surface Mining and the Environment, is one of the few available references on the extent of surface mining in the United States. Bureau of Mines studies are now underway to evaluate the environmental effects of surface mining in the Twin Buttes and Black Mesa areas of the western United States by remote sensing methods. This work is under the supervision of Mr. William C. Henkes, United States Bureau of Mines, as a separate but related effort to the present study.

Dr. Frank J. Wobber (unpublished manuscript)^{/2} used 1:24,000 scale panchromatic photography at a mined land test site in the Prince William State Forest, Virginia. The test area was not typical of disturbed lands in coal-producing areas and the black and white photography apparently lacked sufficient detail for environmental investigations.

Acknowledgements

Earth Satellite Corporation appreciates the cooperation of the many federal representatives, coal producers and state coal associations who provided useful information for this study. Particular thanks are due Mr. Paul M. Marcus, U.S. Bureau of Mines, for his continuing interest and advice throughout the project. Mr. Rod Krause, National Coal Association, made available information concerning coal industry experience in applying aerial photography to reclamation and mined land reclamation information requirements.

^{/1/} Surface Mining and Our Environment, U.S. Department of Interior, 1967. U.S. Government Printing Office, Washington, D.C. 124 pp.

^{/2/} Wobber, F.J. A Study of Acid Pollution in Piedmont Virginia, 1969. Unpublished manuscript, 30 pp.

II. OBJECTIVES

The objectives of the study are:

- To prepare a summary of mined area information requirements to which remote sensing methods might contribute.
- To document remote sensing techniques as applied to mined area reclamation, i.e., problem oriented state-of-the-art summary.
- To inventory remote sensing data banks having imagery potentially useful for studies of coal mined land reclamation.

A literature search revealed early in the study that the multiple, interrelated information requirements of mined area reclamation were apparently not sufficiently organized or detailed for systematic comparison to potentially-contributing remote sensing techniques. This was investigated as a principal part of this study.

III. APPROACH

The following tasks were conducted in parallel. The results were documented as the study proceeded:

Task 1: Review applicable literature and state, federal and mining industry practices to determine how remote sensing techniques are currently being applied to problems of mined area reclamation.

Task 2: To contact federal, state, company and university representatives to determine the extent to which remote sensing is currently applied or being investigated for mined land reclamation.

Task 3: To determine the nature of the remote sensing data used to study mined-land areas and the amount of imagery available in data banks.

It was not entirely possible within the time and cost constraints of the study to fully assimilate information contained in all related literature. Representative publications were however examined when recommended by individuals and groups knowledgeable in reclamation.

IV. COAL MINED AREA RECLAMATION COMMUNITY INTERESTS

Federal Interests

Legal

The federal government has a vital role in mined area reclamation on Indian and public lands. Applicants who intend to mine federal lands are now required to submit a reclamation plan and file a performance bond. Recently, bills were being introduced in Congress, the purposes of which vary from stricter mining reclamation enforcement to the complete abolition of surface mining operations.

Operational Assistance

The federal government and specifically NASA and U.S. Department of Interior have extensive experience in remote sensing applications, which if fully exploited, can address reclamation problem solving. This experience is available to interested state and private groups involved in mined land reclamation.

Education

Many coal companies are unaware of remote sensing capabilities or believe that ground studies and/or black and white imagery provide the only data required for successful reclamation operations. State agencies lack experience in using remote sensing state-of-the-art techniques as do many federal groups. Many state and federal groups charged with reclamation responsibilities rely largely on ground inspections or mine company reports for data acquisition. Such systems of ground investigation (which will always be a necessary part of mine reclamation) might benefit from remote sensing to limit existing time consuming procedures or lack of trained personnel.

Many state and private agencies are particularly concerned about the potential expense of using remote sensing technology and must be provided operational experience (with cost evaluations) before the technology will be widely used.

Inventory

A semi-annual or annual inventory of mined lands could provide the necessary incentive to the mined area reclamation community to apply remote sensing technology. A central data bank which could provide periodic mined land inventory reports could prove immediately valuable to mining companies and state and federal agencies.

State Interests

Legal

States have the responsibility to develop laws which insure the environment is protected. Twenty-four states have surface mining laws which (in general) require the mine operator to meet grading requirements, to dispose of refuse, and to revegetate stripped areas. In most states it is a standard procedure to require the mine operator to post a bond which is not returned until the state is satisfied that reclamation has been effective.

Monitoring

State inspectors regularly conduct field checks to insure that coal companies are complying with state reclamation laws. Some state agencies use aerial photography to supplement their investigations but the majority rely solely on ground observations. As monitoring requirements expand, many states are developing an interest in remote sensing technology. Because of a lack of knowledge as to remote sensing capabilities and at times a reluctance to invest in unproven techniques, states have adopted a wait-and-see attitude. Many states assume that the federal government will provide the needed incentive.

Operational Assistance

Even if states become more involved with remote sensing technology, it is doubtful they will be in a position to transfer this technology to private mining companies. Informal guidance from state agencies for private companies can, however, be anticipated.

Private Interests

A majority of coal companies have a sincere increasing interest in surface mine reclamation and some have voluntarily gone beyond meeting minimum state legal requirements for reclamation.

Most coal companies are directly involved with reclaiming disturbed areas and as such are conscious of the effects which their operations have on the environment. This has not always been true in the past, but serious planning for reclamation has now been introduced into a majority of strip mining operations.

Coal industry groups such as National Coal Association have established information distribution networks which are particularly amenable to introducing remote sensing technology to coal companies.

These groups have historically cooperated with the United States Bureau of Mines and state agencies, and could provide additional leadership in demonstrating the value of remote sensing techniques to reclamation problems.

V. INFORMATION REQUIREMENTS

Reclamation information needs in coal mined areas are categorized in Table 1. These data are based solely on literature review and interviews; the list includes phenomena for which remote sensing imagery could most likely provide identifiable signatures.

General Information Requirements

To inventory extent of disturbance and classify mined lands.

Specific Information Requirements

- Extent of disturbed area
- Acreage of unreclaimed lands
- Acreage of currently-mined lands
- Type of mining (e.g., pit or contour benches)
- Acreage of reclamation completed or in progress
- Culm banks
- Pre-mining ecological record
- Rates of mining progress and spoil generation
- Size of operations
- Presence, type and quantity of mining equipment

To develop a reclamation (user) plan for lands to be reclaimed, to after-uses.

- Pre-mining ecological record
- Access to highways and population centers
- Recreation sites (lakes, dams, camping, etc).
- Fire Lanes
- Hazardous areas
- Existing water bodies
- Land use in adjacent areas
- Water impoundment (runoff holding) sites
- Ground water supplies
- Soil productivity
- Soil texture

To survey the area to be mined and subsequently reclaimed.

- Coal outcrops (evidence of shallow overburden)
- Spoil site locations
- Location of existing toxic materials
- Location of existing acid seepage
- Historical or archaeological site preservation
- Vegetation and wildlife preservation
- Soil types
- Soil productivity
- Available water supplies
- Water supplies affected
- Projected drainage changes
- Utility right of ways
- Area Drainage Patterns

TABLE I. Information Requirements of the Mined Area
Reclamation Community and Principal Phenomena

To determine plant response following reclamation - revegetation

- Vegetative vigor
- Density of vegetative cover
- Areal extent of vegetation
- Type of vegetation
- Cause and extent of vegetative damage
- Rates of vegetative growth
- Natural vegetation on spoil banks
- Seeding and planting ("skip") patterns

To protect and monitor regional water quality

- Areas of "yellow boy" (ferrous anhydride)
- Areas of stream turbidity and sedimentation
- Drainage patterns
- Stream size and flow rates
- Areas of flooding or high water
- Groundwater outfalls
- pH (acidity/alkalinity)
- Areas of acid seepage
- Areas of standing (stagnated) water

To determine the nature of mined area spoil preliminary to regrading and revegetation, and following revegetation

- Spoil texture, rock and particle size
- Porosity
- Color of spoil debris
- Consolidated versus unconsolidated parent materials
- Zones of compaction
- Soil productivity

To determine the composition of mined area spoil preliminary to regrading

- pH (acidity/alkalinity)
- Mineral content of parent material
- Organic nutrient content
- Degree of leaching
- Toxic debris concentrations
- Soil type and profile
- Toxicity of debris

To determine the moisture-holding properties of mined area spoil

- Spoil saturation variations
- Relative permeability
- Zones of infiltration
- Rate of evaporation
- Zones of compaction
- Areas of standing water

To determine the extent to which raw spoil or revegetated areas are subject to erosion or have already been eroded

- Amount and rate of wind/water denudation
- Degree of slope
- Spoil particle size
- Gullying or sheet erosion areas
- Variation in compaction
- Rate of water run-off
- Distribution of exposed soil areas
- Drainage density and patterns
- Areas of vegetation coverage
- Alteration of drainage lines
- Sediment affects on stream flow
- Sediment affects on water quality
- Density of vegetative cover/unit area
- Extent of stream sedimentation (flow retardation, filling, bars, etc.)

To determine the nature of the surface to be cleared and reclaimed

- Frozen and/or saturated areas
- Areas in standing water
- Areas of brush, trees, and outcrops
- Tree diameters
- Tree stump sizes
- Large boulders
- Toxic debris to be buried

To facilitate reclamation backfill and grading operations in mined areas

- Quantity/quality of overburden removed
- Quantity of overburden useful for reclamation
- Sites for storage of overburden

To reduce and predict areas of slope instability

- Zones of spoil saturation
- Location of groundwater outfalls
- Tension cracks
- Fracture systems in high walls
- Slope grade
- Spoil texture
- Nature of the bedrock
- Vegetation root-holding capabilities
- Spoil infiltration rates
- Quantities of vegetation buried by spoil
- Vegetative vigor

To better understand the dynamic processes in progress in reclaimed areas

- Disturbance (erosion) of access roads (fire lanes)
- Disturbance to water locations
- Potential slide areas
- Areas and type of erosion,
- Effects of slopes on reclamation
- Effects of slopes on erosion
- Effects of slopes on run-off stream flow rates
- Sources and rates of sedimentation

VI. SUMMARY OF APPLICATIONS OF REMOTE SENSING IMAGERY

With increasing national concern for protecting the natural environment, there has been a corresponding increase in activity directed toward exploiting technical innovations for reducing ecological damage. Remote sensing technology has developed at a rapid rate from black and white aerial photography to an array of multi-spectral cameras, scanners, spectrometers and radar sensors. Remote sensing techniques applied operationally to mined area reclamation to date are largely confined to large scale black and white aerial photography. Black and white aerial photography is currently an important tool for addressing mined area reclamation problems for many large mining companies, but is often used only as a supplementary field photomap. The vast majority of reclamation data acquisition needs are filled by ground studies. The capabilities of sensor systems have not yet been directed to most problems of mined area reclamation.

Table II specifies the extent to which a variety of organizations concerned with mined land reclamation have applied remote sensing to reclamation problems. Additional operational experience in the application of remote sensing technology for solving reclamation problems is still required. Experimental studies of most mined area problems have yet to be conducted, and few are currently in progress or being planned.

Vertical aerial photography has been used almost exclusively to date. In a few cases, low oblique photographs have been obtained from light aircraft using hand-held cameras. Based on analysis of hand-held photography, oblique color infrared imagery may contain more useful data than vertical

aerial photography for detecting revegetated areas^{1/} and evidence of plant stress or missed areas, e.g., bare soil areas. This is particularly true where reclaimed land is relatively level; low altitude oblique imaging of vegetated areas may yield less useful information in mountainous terrain (e.g., Appalachian Province) because area coverage will be limited by relief.

Contacts with mined area reclamation user groups suggest that the information needed to define imaging techniques and platform requirements versus mined area reclamation needs in detail (Appendix II) is unavailable. Thorough analysis of imagery in existing data banks and/or new aerial data acquisition is required to establish the utility of remote sensing for mined areas reclamation purposes.

The frequency of observation required to inventory mined lands requires a further evaluation of federal and state laws. Some mining companies collect monthly aerial photographic coverage of reclaimed areas for reclamation planning before mining operations begin; other companies limit coverage to once or twice a year. A minimum semi-annual survey period will probably be required to meet most state and federal inventory needs, i.e., to inventory mined lands. A period of up to three years might be required before the success or failure of revegetation could be fully evaluated.

^{1/} The usefulness of oblique imaging may extend to detection of tension cracks indicative of unstable slopes, analysis of stream sedimentation or studies of acid water discharge.

Wobber (1971)^{1/} is currently investigating the utility of snow cover for enhancing terrestrial features; snow enhancement techniques are being evaluated for their application to mined area reclamation.

^{1/} Wobber, F. J., 1971. Discrimination of Terrestrial Phenomena Using Snow Enhancement Techniques. (Publication expected, 1972).

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|---|-----------------|---|--|---|--|
| ENOS COAL CORP. | B & W | 1:2400 reduced to 1:4800 or 1:6000 scale | Before Mining After Mining Reclamation Planning Monitor Reclamation Progress Historical Environmen- tal Record Update Company Maps Meet State/Federal Laws | Size of Area to be Reclaimed Re-vegetation of Stripped Area Vegetative Growth-Survival Acid Drainage Compaction | <ul style="list-style-type: none"> Image bank goes back to 1965 when used for contour mapping purposes. Been using imagery for reclamation purposes since 1967. Imagery-available for reference |
| INDIANA COAL ASSOCIATION | N/A | N/A | N/A | Re-vegetation Ph Soil-water Rockiness of Area Iron Content Volume Flow | <ul style="list-style-type: none"> All work is done by ground studies at present. |
| Table II Remote Sensing Applications by selected representatives of the Mined Area Reclamation Community. | | | | | |

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|------------------------|------------------------------|--|---|--|----------|
| PEABODY COAL CO. B & W | 1:4800 scale 1:6000 scale | Before Mining (topography) After Mining Reclamation Planning Monitoring Reclamation Progress Historical Environmental Record Update Co. Maps Meet State/Federal Laws Engineering Yardage/tonnage overburden Size of Area to be reclaimed Number of Acres Graded/ Month | Revegetation Grading Acid Pollution Soil Type Soil Compaction | <ul style="list-style-type: none"> • Fly once a month for yardage/tonnage, overburden and grading. • Fly once a year to check vegetation progress. • Imagery goes back to 1964 • Imagery available for reference if cleared. | |

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|---------------------------|----------------|--|---|---|---|
| NATIONAL COAL ASSOCIATION | B & W | 1:7200 scale 1:4800 scale 1:3600 scale | Reclamation Planning Monitoring of Reclamation Progress Meet State/Federal Laws | Quantity of material moved from piles into usable slopes Toxic elements presence and distribution. Effects on water quality. Siltation and sedimentation Capability of soil to produce Acres-"skip" patterns Mine Seepage Land use Planning Total area regraded Total area revegetated | <ul style="list-style-type: none"> • Have an interest in the all-weather capability of SLAR (side-looking airborne radar) • Annual flights monitor creep and bulges indicate areas of slide. |
| HANNA COAL CO. | B & W Color | 1:6000 scale | Before Mining After Mining Reclamation Planning Monitoring of Reclamation Progress Update Company Maps Meet State/Federal Laws | Soil Analysis Re-vegetation Water Sources Slide Areas Area affected by stripping Regrading | <ul style="list-style-type: none"> • Company uses 2 Kelsh Stereo Plotters. • Imagery used for approximately 12 years. • Imagery available for reference. • Color for publicity purposes • Imagery flown once a month. • Have electronic readout system. |

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|------------------------------|----------------------|---|---|--|---|
| OHIO RECLAMATION ASSOCIATION | B & W I/R | 1:9600 scale 1:12000 enlarged to 1:3600 or 1:6000 scale | Before Mining After Mining Reclamation Planning Monitoring of Reclamation Progress Historical Environmental Record Update Company Maps Meet State/Federal Laws Engineering Mapping Surveying | Amount of earth moved Drainage patterns Topography Revegetation Acid drainage Re-grading | <ul style="list-style-type: none"> • Company checks progress of vegetation by ground study. • Company has used IR on a very limited basis. |
| PRIVATE FLYER | B & W Color IR | 1:9600 scale or 1:12000 enlarged to give 1:3600, 1:6000 | Before Mining After Mining Reclamation Planning Monitoring of Reclamation Progress Historical Environmental Record Update Company Maps Meet State/Federal Laws | Amount of water impoundment Drainage Stream Flow Access Roads Surface Area to be re-claimed Toe of Spoil Highwall specifications | <ul style="list-style-type: none"> • Imagery is available for reference if cleared by companies for which he flies. • Has black and white imagery which dates back to 1951. • Has taken color imagery for last 5 or 6 years. • Has been taking IR for one year. • Some imagery has been accumulated using hand-held cameras. |

PRIVATE

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|---|-----------------|------------------------------------|--|----------------------|--|
| R.H. LUDWIG & COMPANY (Engineers) | B & W | 1:2400 scale | Mapping Purposes | --- | <ul style="list-style-type: none"> • Have imagery dating back 3 years on coal areas. • Imagery - available with coal company's permission. • Fly twice a year for one company. • Fly for 5 or 6 coal companies. • Keep negatives on file at their location. |
| AERIAL MAPPING COMPANY (Pittsburg, Pa.) | B & W | 1:24000 1:24000 enlargements | Planimetric mapping State Reclamation Subsidence determination | --- | <ul style="list-style-type: none"> • Deal with about 10 coal companies. • Negatives kept on file at their location • Available for reference with coal company's permission. • Imagery dates back to 1954 • Fly Kentucky, Tennessee, Pennsylvania, Ohio and West Virginia. • Do interpretation work. |

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|---|-----------------|------------------------------|--|----------------------|--|
| PARK AERIAL SURVEYS, Inc. (Louisville, Kentucky) | B & W | 1:4800 scale 1:1200 scale | Overburden Estimate Area Disturbed Area Reclaimed Coal Location Mapping Inventory | --- | <ul style="list-style-type: none"> • Imagery dates back to 1945. • Fly for Peabody, Consolidation Enos and Arch. • Coal companies do interpretation for reclamation purposes. • Negatives on file at their location. • Available for reference with permission of coal company. |
| SURDEX CORP. (Chesterfield, Missouri) | B & W | 1:9600 scale 1:6000 scale | Mapping Pit Surveys Overburden and coal removal | --- | <ul style="list-style-type: none"> • Imagery dates back 12-15 years. • Fly for approximately 6 coal companies. • Topographic and planimetric mapping. • Coal company does interpretation for reclamation purposes. |

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|------------|-----------------|-------|--------------|----------------------|----------|
|------------|-----------------|-------|--------------|----------------------|----------|

SURDEX CORP.
(Chesterfield,
Missouri)
cont.

• Fly as far east as
Indiana.

• Imagery available for
reference with permis-
sion of coal company.

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|---|---------------|-------|--------------|--|---|
| KENTUCKY DIVISION OF RECLAMATION | Black & White | -- | -- | <p>Law Enforcement</p> <p>Has company met standard with regard to:</p> <p>Access Roads</p> <p>Backfilling</p> <p>Grading</p> <p>Water Impoundments</p> <p>Acid Mine Drainage</p> <p>Acid Materials</p> <p>Methods of Operation</p> <p>Revegetation</p> | <ul style="list-style-type: none"> • The Kentucky Division of Reclamation enforces mining legislation. • Their inspectors work in the field when looking for violations of reclamation laws. • Information needs listed are taken from "Kentucky Revised Status Relating to Strip Mining and Reclamation and are not a result of a direct interview. • They fly areas occasionally and acquire imagery. |
| WEST VIRGINIA DEPARTMENT OF NATURAL RESOURCES | -- | -- | -- | <p>Determination of sufficient soil cover to support vegetation.</p> <p>Proper drainage</p> <p>Proper grading</p> <p>How well vegetation is established</p> <p>Soil pH</p> <p>Soil color</p> <p>Causes of slides</p> <p>Amount of erosion in watershed</p> | <ul style="list-style-type: none"> • Do not use aerial photography in area of reclamation. • Soil color is an important factor in determining the amount of heat absorbed and subsequent survival of newly planted seedlings • Soil temperatures in the same area can vary as much as 25°F depending upon the soil color. |

STATE

GROUP NAME TYPE IMAGERY SCALE APPLICATIONS INFORMATION NEEDS COMMENTS

| | | | | | |
|---|-------------------------------------|--------------|---------------------|--|--|
| SURFACE MINE- LAND USE BOARD (Georgia) | -- | -- | -- | Land description Physiographic features Water impoundments Access roads Revegetation Grading Toxic materials Land use map | <ul style="list-style-type: none"> Check the progress of mine company reclamation by ground studies only. Mining companies submit either maps or photos which show re-claimed areas in order to fulfill Surface Mine Land Use Board rules. Information needs come from their regulations. |
| DEPARTMENT OF NATURAL RE- SOURCE (Div. of Forestry and Reclamation) Columbus, Ohio | -- | -- | -- | Land Use Map Regrading Revegetation | <ul style="list-style-type: none"> Concerned with making sure coal companies meet their reclamation requirements. Inspectors go into the field to check the progress of reclamation activities. |
| DEPARTMENT OF ENVIRONMENTAL RESOURCES Harrisburg, Pa. | Black & White IR (Thermal) | 1:4800 scale | Determine area size | Size and extt of area stripped | <ul style="list-style-type: none"> Most imagery used comes from state and federal sources. Thermal infrared has been used to locate mine fires. Do not keep imagery on hand at their location. 1966-67: Entire anthracite region flown. |

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|---|-----------------|-------|--------------|--|--|
| APPALACHIAN REGIONAL COMMISSION Washington, D.C. | -- | -- | -- | <p>Status of area before mining</p> <p>Coal outcroppings</p> <p>Distribution of mined area debris</p> <p>Number of contour benches necessary</p> <p>Soil type</p> <p>Vegetation affected by stripping</p> <p>Location and type (surface and sub-surface) of drainage</p> <p>Changes which have occurred as a result of stripping and reclamation</p> | <ul style="list-style-type: none"> Listed a number of coal company information needs. Appalachian Regional Commission does not collect aerial photography. |

UNIVERSITIES

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|-------------------------------|-----------------|-------|--------------|----------------------|---|
| PURDUE UNIVERSITY | -- | -- | -- | -- | • Have used remote sensing extensively but not for mining reclamation. |
| UNIVERSITY OF KENTUCKY | -- | -- | -- | -- | • Involved with under- ground mining only. |
| UNIVERSITY OF PENNSYLVANIA | -- | -- | -- | -- | • Has not used aerial photography for mining reclamation purposes. |

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|--|---------------------|--------------------|---|--|---|
| TVA MAPS AND SURVEY BRANCH (Chattanooga Tennessee) | B & W Thermal IR | 1:20,000 1:9600 | Before Mining After Mining Reclamation Mining Historical Environmental Record Update Company Maps Meet State/Federal Needs | Soil Mineral Content Drainage Water Pollution Mine Seepage | <ul style="list-style-type: none"> • Have imagery dating back 35 years. Have been flying consciously over stripped areas for past 18 years. • Data Bank is available for reference and should provide the most extensive strip mining area coverage available. • Thermal infrared has been used, but to a very limited extent. |
| BUREAU OF LAND MANAGEMENT | B & W | 1:15840 | Before Mining After Mining Reclamation Planning | Multiple Use Planning Management Requirements Drainage Topography Vegetation Types Mineral Types Geology (coal outcrops) Wind Blown Dust Distribution | <ul style="list-style-type: none"> • Bureau sees to it that surface mined lands have adequate reclamation planning and that regulations with respect to reclamation planning are followed. • Their primary goal is to put the land back into a usable state. • Imagery is turned over to U.S.G.S. for storage. |

GROUP NAME TYPE SCALE APPLICATIONS INFORMATION NEEDS COMMENTS

| | | | | | |
|--|-------|---|-----|-----|--|
| U.S. DEPT. OF AGRICULTURE: SOIL CONSERVATION SERVICE | B & W | 1:8000 to 1:70,000 coverage by counties | --- | --- | <p>• SCS uses B&W photography for soil mapping purposes. SCS covers county unit areas and photograph approximately 40 counties/yr.</p> <p>• Index maps are available showing coverage to date and the imagery is available for review. Imagery may cover Appalachian and Mid-west coal areas, but imagery is not flown for the purpose of mine reclamation or mine observation in these areas.</p> |
|--|-------|---|-----|-----|--|

| | | | | | |
|--|--|-----|-----|--|-----|
| U.S.D.A. - FOREST SERVICE: DIVISION OF WATERSHEDS and MINERALS | | --- | --- | <p>Success of Vegetation</p> <p>Soil and Water Preservation</p> <p>Acid Pollution</p> <p>Stabilization</p> <p>Return to Productive Use</p> <p>Examination of End Product</p> | --- |
|--|--|-----|-----|--|-----|

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|---|-----------------|----------|---|--|---|
| U.S. BUREAU OF MINES: DIVISION OF ENVIRONMENT | --- | --- | After Mining to Determine Area Disturbed | Inventory--total acreage of unreclaimed surface mined land. Extent of Disturbance How Disturbed Type of Mining Composition of Materials (Toxic) Plan for Reclamation-- Most Rapid Stabilization | <ul style="list-style-type: none"> • IR Thermal Scanners have been used to locate underground mine fires and burning culm banks. • Maps are updated showing surface expressions of anomalies. • Anthracite region has been overflown with IR Thermal Scanner at approx. scale of 1:1000. |
| U.S.D.A.- FOREST PROD- UCTS MARKETING LAB. (Prince- ton, W. Va.) | B & W | 1:20,000 | Acreage Disturbed Condition of Area Water Resource Location | Acreage Disturbed Condition of Area | <ul style="list-style-type: none"> • Study covered 7.5 million acres of lands in eastern Kentucky of which about 1% was surface mined. • Imagery stored at Berea, Kentucky Northeastern Forest Experiment Station. <p>Available for reference.</p> |

| GROUP NAME | TYPE IMAGERY | SCALE | APPLICATIONS | INFORMATION NEEDS | COMMENTS |
|------------|-----------------|-------|--------------|----------------------|----------|
|------------|-----------------|-------|--------------|----------------------|----------|

| | | | | | |
|---------------------------------------|-----|-----|-----|-----|---|
| NASA MANNED SPACE FLIGHT CENTER | --- | --- | --- | --- | <ul style="list-style-type: none"> • Approximately 13 NASA sites have been overflown which may contain surface mined areas. The imagery is stored at the Manned Space Flight Center in Houston. • Requires intensive analysis to determine applicability to mined land reclamation. |
|---------------------------------------|-----|-----|-----|-----|---|

APPENDIX I

10 May, 1971

MINED AREA RECLAMATION INTERVIEW RECORD

Agency/Firm: _____

Representative (Name): _____

Address : _____

Telephone : _____

A. Mined Area Reclamation Information Needs and Data Categories.

[illegible]

Information and Data Needs Listed in Order of Importance?

YES



NO



No

☐

Procedures being Used

C. Description of Image Data Bank

| <u>Type Imagery</u> | <u>Scale</u> | <u>Used How Long</u> | <u>Source</u> |
|---------------------|--------------|--------------------------|---------------|
| <hr/> | <hr/> | <hr/> | <hr/> |
| <hr/> | <hr/> | <hr/> | <hr/> |
| <hr/> | <hr/> | <hr/> | <hr/> |
| <hr/> | <hr/> | <hr/> | <hr/> |
| <hr/> | <hr/> | <hr/> | <hr/> |

Area Covered

Available for Reference:

YES

☐

NO

☐

Location of Data Bank:

Address as above:

☐

APPENDIX II

Remote Sensing Applications Form
(Source: EarthSat)

[illegible]

LEGEND:

| | |
|-------------|----------------------|
| | Panchromatic (P) |
| | Color (C) |
| | B&W Infrared (B&WIR) |
| Photography | Color Infrared (CIR) |
| | Multispectral (MS) |
| | Vidicon (V) |

THERMAL INFRARED IMAGERY
(TIR)

RADAR
IMAGERY
(RAD)

ULTRAVIOLET
IMAGERY
(UV)

